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Abstract

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The ability of readers to correctly age rainbow trout was tested using scales from hatchery trout marked and released as spring yearlings. After an initial learning phase, accuracy averaged 78% (range 73-85%). Neither the differences in accuracy among readers nor a tendency to underage was significant. Readers tended to make the same errors on individual scales, but most errors could be detected by discrepancies among pairs of readers. Errors in ageing had little effect on estimates of age structure or length at age 2+ for this data set in which readers discussed the true age of each scale before proceeding to the next. Estimated age structure was 16% 1+, 57% 2+ and 27% 3+ and older, whereas the true age structure was 18% 1+, 50% 2+ and 32% 3+ and older. Estimated and true mean lengths at age 2+ were 304 and 301 mm, respectively. The small size of these discrepancies may be due to prior expectations and the continual feedback on true values for this data set.

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INTRODUCTION

Ageing errors, particularly when bias is involved, can have serious effects on the estimation of population parameters, such as growth and survival, that are important in fisheries management (Beamish and McFarlane 1983, Lai and Gunderson 1987). Beamish and McFarlane (1983) emphasize the importance of validation of ageing techniques since age determination is often subjective, and systematic errors are common. The purpose of this study was to estimate the accuracy of age determination for scales from marked rainbow trout stocked as yearlings into a variety of small, southern British Columbia lakes.

The effect of ageing errors depends on the details of the magnitude and direction of bias and the size of the error variance and is therefore specific to each ageing exercise. A secondary purpose of this study was to use the replication among readers to provide an estimate of the effect of ageing errors on an index of growth (length at age 2+) and the age structure of this population.

Three of the most common validation techniques are: comparisons among readers, comparisons among structures (eg. otoliths vs. scales), and comparison with known age (usually marked) fish. Comparison among readers addresses only the issue of precision or reproducibility rather than accuracy but is the most common method of age "validation". The third purpose of this study was to determine if disagreement between readers was a useful indication of inaccuracy in this data set.

METHODS

Scales of known age were collected from rainbow trout stocked as spring yearlings which were marked with fin clips or fluorescent grit prior to release. Fish were collected either by variable mesh gillnet or from anglers. Length, fin clip and state of maturity were recorded for each fish. Actual ages ranged from 1+ to 5+ years.

Impressions of scales were made on acetate sheets and printed on a microfiche reader using the methods of Tsumura (1987). Only good reproductions with clear, sharp circuli were used. Readers were provided with photocopies and overhead projections of microfiche prints. Original impressions, projected on a microfiche reader, were also available for reference.

Scale ageing techniques and characteristics of annuli were reviewed first in a presentation and then with a selected sample of 10 scales where the number of annuli was known but annuli locations were unknown. Compression of circuli, cutoff circuli and crossovers seemed to be the best indicators of annuli location. A random sample of 78 scales, selected from the 245 available, was then aged independently by each of 10 readers. Experience of individual readers was difficult to quantify but all had some scale

reading experience, and 6 out of 10 read scales as a regular part of their job.

Initial estimates were made using only the date of capture and state of maturity of the fish as supplementary information. Few changes in ages were made after the length at capture was given, and only the results of the first estimation are given here. Readers received further training as part of the ageing exercise. After estimating the age of each fish, readers were given the true age and the group discussed the probable locations of the annuli before ageing the next scale.

RESULTS AND DISCUSSION

Error Rate

Accuracy for the 10 readers on the 78 scales averaged 73.5% overall but accuracy improved after an initial learning phase (Fig. 1). Accuracy for the first and second halves of the data differed and averaged 69% and 78%, respectively ($P<.01$, G-test, Sokal and Rohlf 1981). The first half of the scales were therefore treated as a training exercise and further analysis only involved the last 40 samples.

Accuracy of individual readers on the last 40 scales ranged from 72.5% to 85% but this variation was not significant ($P=.914$). Of the 87 errors made, 56 (64%) were lower than the true age and 31 (36%) were higher, but this difference was not significant ($P=.065$). Among readers, the percentage of errors that were underage ranged from 50% to 89% but this variation was not significant ($P=.251$).

Measurements of accuracy in ageing studies are necessarily specific to individual situations since they depend on factors such as fish species, growth rates, preparation techniques, structures aged and reader experience. Ageing accuracy in salmonids has ranged as high as 95% in scales from young, immature fish but is generally lower when older or maturing individuals are included (eg. Hesthagen 1985). In some cases, specific problems in locating a particular annulus can be identified (Davis and Sloane 1986, Mann and Steinmetz 1985). In the present data set, both under and over-ageing occurred and errors were not consistently associated with a particular annulus.

A small percentage of the scales accounted for most of the errors: 38% of the errors were made on 10% of the scales and 75% of the errors were made on 30% of the scales. Thirty-five percent of the scales were aged correctly by all 10 readers.

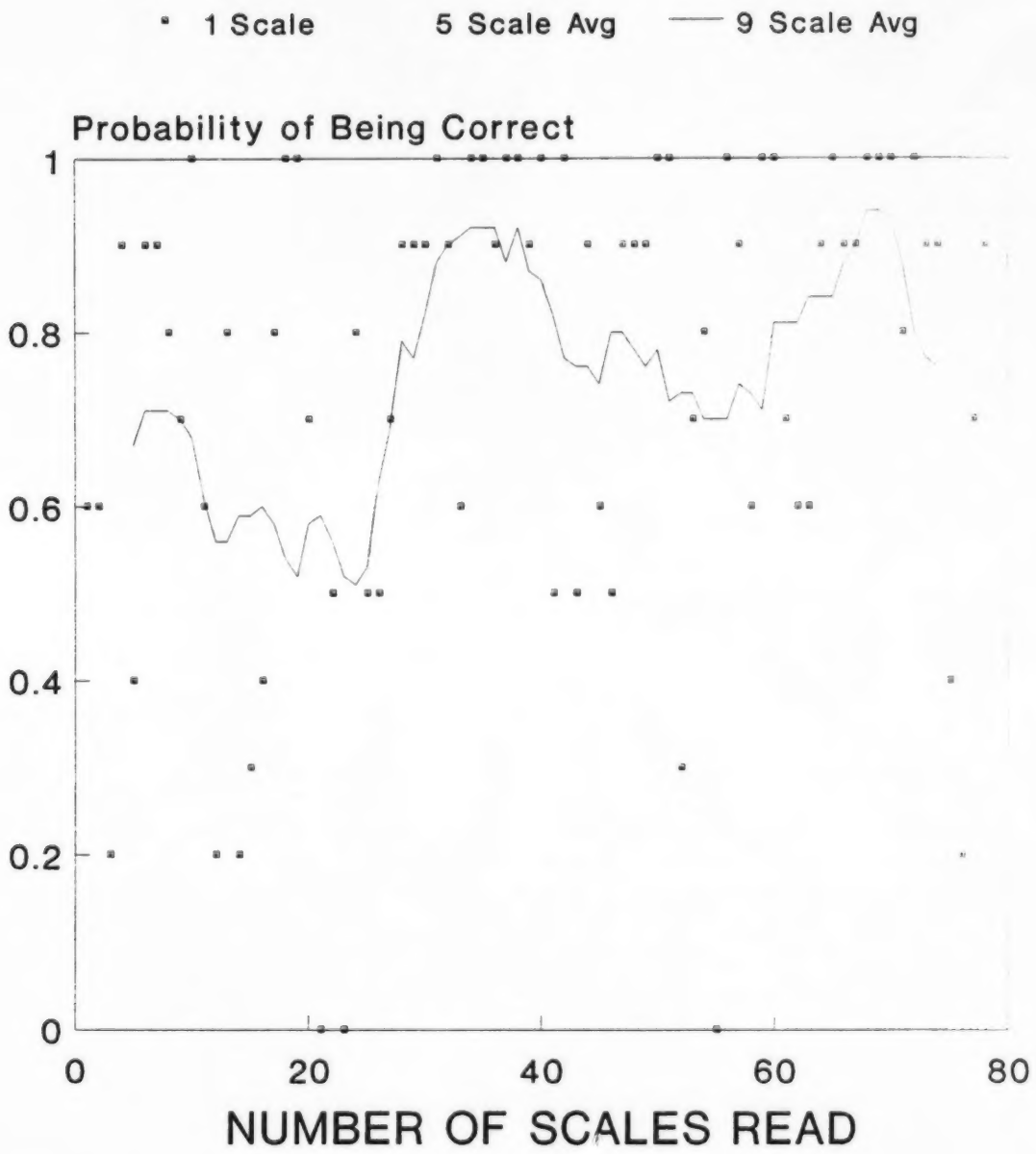

Figure 1. Ageing accuracy for individual scales by 10 readers as a function of the number of known-age scales analyzed and discussed in a scale reading workshop.

Reader Consistency

When more than one reader made an error on the same scale there was a strong tendency for the errors to be identical. Out of the 188 possible pairwise comparisons between two readers where both readers made an error on the same scale, only 6 involved a discrepancy between readers. In spite of this tendency, discrepancies among readers were a fairly good way of identifying errors. Of the 567 possible pairwise comparisons between two readers where one or both readers made an error on the same scale, 395 (68.5%) involved a discrepancy between readers. In virtually all of these cases (389) one of the readers had aged the scale correctly.

The problem of false consistency is reduced by using three readers. Only 15% (292) of all 3-way comparisons in which one or more readers were in error involved an identical mistake by all three readers.

These results indicate that, although many errors result in discrepancies among pairs of readers, agreement among pairs of readers may mask a significant proportion of errors. In this data set, correct resolution of pairwise discrepancies would still leave a 10% error rate due to false consistency among pairs of readers. Using 3 or more readers will reduce this problem, but it should be noted that on one of 40 scales all 10 readers gave the same incorrect age.

Effects of Errors on Indexes of Growth and Survival

In this data set, errors had little effect on an index of growth rate (length at age 2+). Out of 40 scales, 20 were actually age 2+ but the number that were aged as 2+ by the 10 readers ranged from 19 to 28 (Table 1). None of the mean lengths at age 2+ estimated from the individual reader's data differed significantly from the actual mean, and grand mean from all 10 readers was only 3.6 mm (1.2%) larger than the actual mean. It should be noted that the length at age 2+ from this data set has an unusually large variance associated with it since the scales were from a variety of lakes and months of the year. In a more typical data set, scales would be from a single lake and time of year. Variances would be smaller that in the present data set and smaller differences would become statistically significant.

For this data set, errors by readers also resulted in very small deviations from the true age composition (Fig. 2). Heterogeneity among readers was less than expected ($P = .93$). Readers did not collaborate but did have frequent discussions on ageing criteria and age structure which may have produced unexpected homogeneity.

Table 1. True length at age 2+ and reader's estimates for the last 40 scales.

	N	MEAN (mm)	S.D.	S.E.	MINIMUM (mm)	MAXIMUM (mm)
Actual Data						
	20	301.0	55.1	12.3	180	396
Readers Data						
1	22	323.3	63.9	13.6	180	441
2	19	307.5	68.2	15.6	180	441
3	25	310.6	66.1	13.2	180	441
4	21	284.3	67.0	14.6	161	441
5	24	310.9	62.2	12.7	180	441
6	22	308.1	63.1	13.5	180	441
7	23	309.9	61.2	12.8	180	441
8	28	297.3	69.7	13.2	161	441
9	20	294.0	63.1	14.1	180	441
10	22	300.1	63.4	13.5	180	441
GRAND MEAN		304.6	10.9	3.5		

The small differences between the actual values and reader estimates of both the age structure and the length at age 2+ are surprising in light of the 22% error rate on individual scales. The major problem with the interpretation of these results is the format which was designed for training rather than testing. Prior expectations and the continual feedback of information on true length at age and age composition are probably part of the explanation of the much better than expected performance in these areas. After an initial learning phase, readers began to expect that most fish would be age two and that the length of age 2+ fish would be about 25-35 cm.

Preconceived notions on age structure and growth rate would tend to reduce the power of tests designed to detect differences between lake or between different management strategies within a lake. A better test of true performance would be a format where readers received training on known age scales but no feedback on test scales. Readers would be tested on their ability to distinguish 2 data sets which differ in both growth rate and age composition.

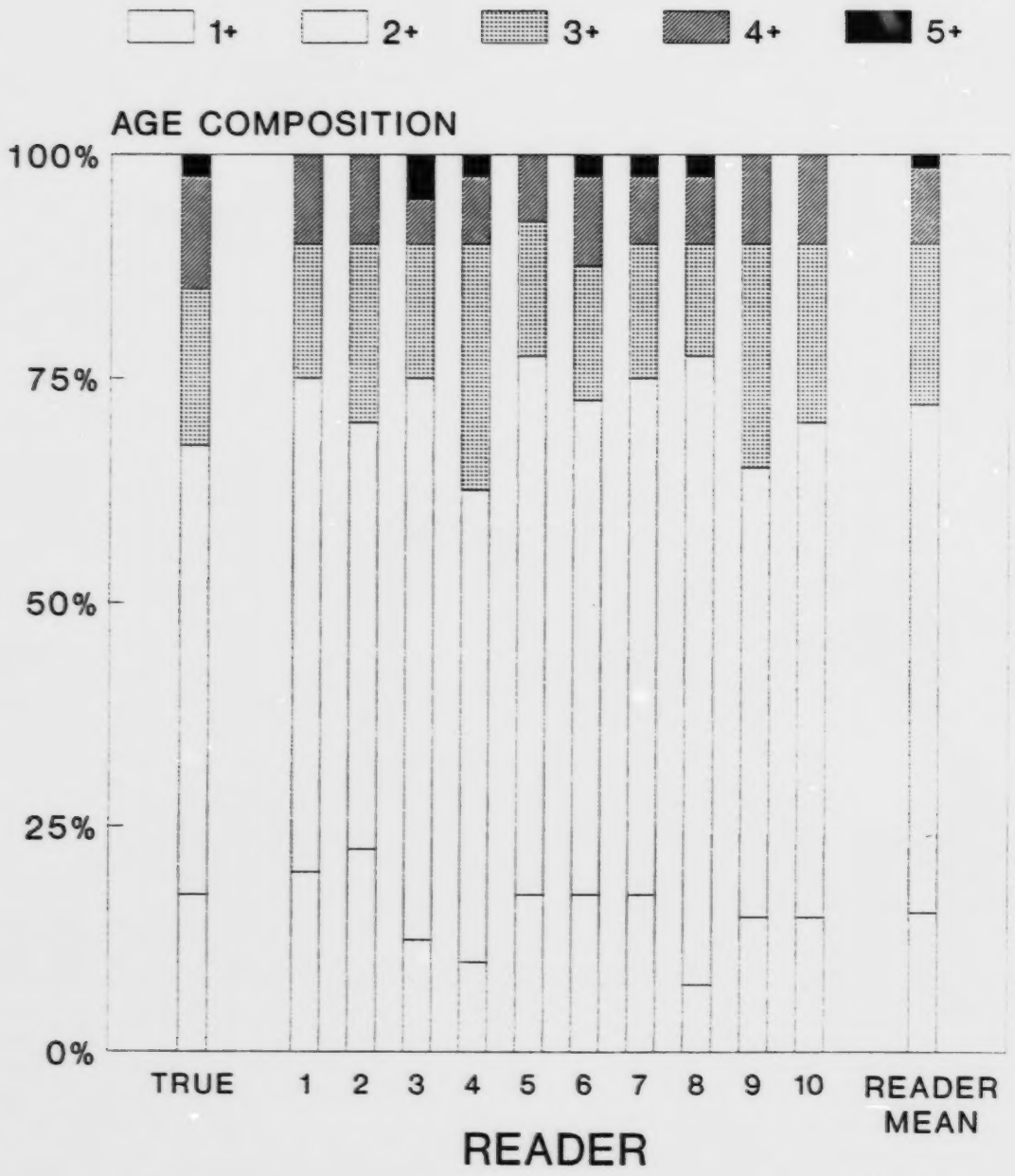

Figure 2. Age composition of the last 40 scales for each of 10 readers. The mean given is for all 10 readers.

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